REMARKS

Claims 1-17 are pending in the application, with claims 16 and 17 having been withdrawn from consideration.

It is believed that this Amendment is fully responsive to the Office Action dated **December 3, 2002**.

Claim Rejections under 35 USC §112

Claims 4, 6, 8, 10 and 12 are rejected under 35 USC §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

It should be noted that the Office complained that the range from 0.2% to 0.6% is not recited anywhere in claims 4, 6, 9, 10 and 12. The complained range is solely hypothetically generated by the Office. Therefore, the Office is in fact rejecting these claims by imposing hypothetical problems that do not exist.

Further in response, these claims are amended based on Eq. (7) in page 13 of the specification in conformity with the original disclosure. Thereby, it was clarified that the strain ε is represented in terms of percent and the thickness L is represented in terms of microns. Further details are described on page 10, lines 24-25 and page 11, lines 11-13.

Reconsideration and withdrawal of this rejection are respectfully requested.

<u>**Claim Rejections under 35 USC §102**</u>

Claims 1 and 7 are rejected under 35 USC §102(b) as being anticipated by JP 7-074381.

Claims 1-8 are rejected under 35 USC §102(b) as being anticipated by Tsuji et al. '068.

The object of the present invention is to provide a semiconductor photodetection device extending optical sensitivity to the side of long wavelength band and uses a strained optical absorption layer. In order to facilitate optical absorption efficiency in the optical absorption layer, the thickness of the optical absorption layer is increased and the thickness of the strain-compensation layer is decreased, by increasing the strain in the strain-compensation layer and decreasing the strain in the optical absorption layer as set forth in amended claim 1.

JP '381 describes alternate stacking of a strained optical absorption layer and a strain compensation layer, while it is noted that the strain in the optical absorption layer and the strain in the strain compensation layer are symmetric and thus have the same magnitude. Thus, the reference suffers from the problem of poor optical absorption efficiency, which is the problem addressed by the present invention.

Similarly, Tsuji merely teaches a structure in which the compressive strain in the optical absorption layer and the tensile strain in the strain-compensating layer are symmetrical and thus have the same magnitude.

Independent claim 1 of the present invention has specifically stated that:

" 1. A semiconductor photodetection detector, comprising:
a semiconductor substrate of a first conductivity type;
a photodetection layer formed on said semiconductor substrate;
a region of a second conductivity type opposite to said first conductivity type being formed in a part of said photodetection layer; and

an electrode applying an electric field to said photodetection layer via said region of said second conductivity type such that said electric field acts in a thickness direction of said photodetection layer,

said photodetection layer comprising: a first semiconductor layer having a first thickness and accumulating therein a compressive strain and absorbing an optical radiation; and a second semiconductor layer having a second thickness smaller than said first thickness and accumulating therein a tensile strain, said first semiconductor layer and said second semiconductor layer being stacked alternately and repeatedly in said photodetection layer."

This claim is supported by way of Figures 3 and 7, wherein there is indeed shown, by way of an example, a semiconductor photodetection detector, comprising a semiconductor substrate 11 of a first conductivity type; a photodetection layer 12 formed on said semiconductor substrate 11; a region of a second conductivity type13 opposite to said first conductivity type being formed in a part of said photodetection layer 12; and an electrode applying an electric field to said photodetection layer 12 via said region of said second conductivity type such that said electric field acts in a thickness direction of said photodetection layer 12; said photodetection layer 12 comprising a first semiconductor layer 12A having a first thickness lb and accumulating therein a compressive strain and absorbing an optical radiation; and a second semiconductor layer 12B having a second thickness lw smaller than said first thickness lb and accumulating therein a tensile strain, said first semiconductor layer 12A and said second semiconductor layer 12B being stacked alternately and repeatedly in said photodetection layer 12.

In rejecting the claimed invention, the outstanding Office Action has specifically pointed to Figure 6 and column 10 of Tsuji et al., alleging that the claimed invention is anticipated. However, from reviewing Tsuji et al., the Applicant simply cannot find the structure and functions as specified in claim 1 of the present invention.

It is well settled that:

> A claim is anticipated only if each and every element *as set forth in the claim* is found, either expressly or inherently described, in a single prior art reference." *Constant v. Advanced Micro-Devices, Inc.*, 848 F.2d 1567, 7 USPQ2d 1057 (Fed. Cir. 1988)."

Therefore, the claimed invention is not anticipated by the asserted prior art because the outstanding Office Action fails to indicate where each and every element is disclosed. In the interest of advancing the prosecution of this application, independent claim 1 is amended to include:

> "wherein said tensile strain in said second semiconductor layer has a magnitude larger than a magnitude of said compressive strain in said first semiconductor layer."

Should the Office continue to believe that the claimed invention is anticipated by the asserted prior art, a citation of where each and every claimed feature, either as column number and line number, or figure number and reference numeral, or a combination thereof, as disclosed in the asserted prior art is respectfully requested. Should the Office determine that any claimed feature is not disclosed in the asserted prior art, it is respectfully submitted that the claimed invention is not anticipated by the asserted prior art. Allowance of the claimed invention is then respectfully requested.

Claims 1, 4, 7-9 and 11-15 are rejected under 35 USC §102(e) as being anticipated by Dries et al. '152.

Dries uses a highly compressively strained InGaAs QW for optical detection, wherein it is noted that the optical absorption layer has a small thickness of 60A and a large compressive strain

while there is provided a graded strain-compensating structure having a thickness of 131A (=45+16+70). Here, it is further noted that there is provided a barrier layer of In083Ga.17P accumulating a tensile strain and having a thickness of 70A.

Thus, Dries is exactly opposite to the subject matter of the present invention as set forth in claim 1. Because of the reduced thickness of the optical absorption layer (In.83Ga.17As-well), the device of Dries suffers from the problem of poor efficiency of optical absorption.

In rejecting the claimed invention with Dries et al., the outstanding Office Action also fails to pinpoint where specifics of the claimed invention are disclosed or taught in the prior art. Independent claim 1 of the present invention has specifically recited a plurality of elements, a structure as well as numerous features obtained therefrom. Since the outstanding Office Action fails to disclose these claimed elements, structure and functions, the claimed invention is not anticipated by Dries et al.

Should the Office continued to believe that the claimed invention is unmistakably disclosed in Dries et al., to assist the Office to substantiate its contention, the following claim language with parenthetical blanks to communicate where each element and feature is disclosed in Dries et al. is provided for the convenience of the Office:

1. A semiconductor photodetection detector ( ), comprising:

a semiconductor substrate ( ) of a first conductivity type ( );

a photodetection layer ( ) formed on said semiconductor substrate ( );

a region ( ) of a second conductivity type ( ) opposite to said first conductivity type ( ) being formed in a part ( ) of said photodetection layer; and

an electrode ( ) applying an electric field ( ) to said photodetection layer ( ) via said region ( ) of said second conductivity type ( ) such that said electric field ( ) acts in a thickness direction ( ) of said photodetection layer ( );

said photodetection layer ( ) comprising: a first semiconductor layer ( ) having a first thickness ( ) and accumulating therein a compressive strain ( ) and absorbing an optical radiation ( ); and a second semiconductor layer ( ) having a second thickness ( ) smaller than said first thickness ( ) and accumulating therein a tensile strain ( ), said first semiconductor layer ( ) and said second semiconductor layer ( ) being stacked alternately ( ) and repeatedly ( ) in said photodetection layer ( );

wherein said tensile strain ( ) in said second semiconductor layer ( ) has a magnitude ( )larger than a magnitude ( ) of said compressive strain ( ) in said first semiconductor layer ( ).

Should it be determined that any aspect of the claimed invention is not disclosed in the applied prior art, it is respectfully submitted that the claimed invention patentably distinguishes over the applied prior art. Allowance of the claimed invention is then respectfully requested.

Claim Rejections under 35 USC §103

Claim 9 is rejected under 35 USC §102(b) as anticipated by or, in the alternative, under 35 USC §103(a) as obvious over JP '381.

Since independent claim 1, as mentioned hereinabove, patentably distinguishes over the applied prior art, by virtue of inherency, all claims dependent thereon, also patentably distinguished over the applied prior art.

Reconsideration and withdrawal of this rejection are respectfully requested.

Claim 10 is rejected under 35 USC §103(a) as being unpatentable over Dries.

Since independent claim 1, as mentioned hereinabove, patentably distinguishes over the applied prior art, by virtue of inherency, all claims dependent thereon, also patentably distinguished over the applied prior art.

Reconsideration and withdrawal of this rejection are respectfully requested.

Prior Art Indicated To Be Pertinent To The Disclosure

The Office has provided a list of prior art indicated to be pertinent to the Applicant's invention. Consistent with the understanding as stipulated in MPEP 706.02 that only the best prior

art should be applied, this list of prior art not having been applied by the Office, it is the Applicant's understanding that the Office must have considered the listed prior art to be no more pertinent than the applied prior art of record.

Conclusion

If, for any reason, it is felt that this application is not now in condition for allowance, the Examiner is requested to contact Applicants undersigned attorney at the telephone number indicated below to arrange for an interview to expedite the disposition of this case.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version with markings to show changes made**."

In the event that this paper is not timely filed, Applicants respectfully petition for an appropriate extension of time. Please charge any fees for such an extension of time and any other fees which may be due with respect to this paper, to Deposit Account No. 01-2340.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE 09/873,264

IN THE SPECIFICATION:

Page 1, paragraph starting at line 17, has been amended as indicated below:

With widespread use of internet, there is emerging tightness of capacity in optical telecommunication network. In order to deal with the problem, the technology of so-called wavelength-division multiplexing (WDM) is now becoming in use. In WDM, plural optical [carries] carriers of different wavelengths are transmitted via a single optical fiber, wherein the optical carriers are modulated with respective modulation signals.

Page 11, paragraph starting at line 5, has been amended as indicated below:

FIG.4 represents the quality of surface morphology obtained for the cap layer 13 when the total thickness Lw of the optical absorption layer 12A and the strain εw therein are changed variously under the constraint that the total thickness L of the superlattice structure 12, and hence the sum of the total thicknesses of the optical absorption layers 12A and the strain-compensating layers 12B, is set to 1.3 μm. From the relationship of Eq.(1), the strain [ε bin] ε b in the strain-compensating layer 12B is given as $\varepsilon b = \varepsilon w \bullet Lw/Lb$. In FIG. 4, the case in which a flat surface morphology is obtained for the cap layer 13 is represented by , while the case in which an irregular surface morphology is obtained is represented by ×.

Page 11, paragraph starting at line 35 and bridging over to page 12, has been amended as indicated below:

It is believed that the surface morphology observed on the surface of the cap layer 12 reflects the surface morphology of the optical absorption layer 12A and the strain-compensating layer 12B in the superlattice structure 12 underneath the cap layer [12] 13. Thus, in the region represented in FIG.4 by ×, it is believed that the regular stacking of the optical absorption layer 12A and the strain-compensating layer 12B is destroyed. Therefore, it is necessary, in view of the result of FIG.4, to chose the thickness Lw of the optical absorption layers 12A and the strain εw so as to fall in the region of excellent surface morphology defined by Eq.(2) when the superlattice structure 12 of FIG.3 is to be used for the photodetection layer of a semiconductor photodetection device.

Page 16, paragraph starting at line 34 and bridging over to page 17, has been amended as indicated below:

Referring to FIG.7, the semiconductor photodetection device 30 has a general construction similar to the conventional semiconductor photodetection device 20 explained with reference to FIG.1 except that the photodetection layer 3 is formed of an alternate repetition of an InGaAs optical absorption layer 3a having a thickness of 20 nm and accumulating a compressive

strain of +0.4 % and an InGaAs strain-compensating layer 3b having a thickness of 10 nm and accumulating therein a tensile strain of -0.8%. In the superlattice structure of the photodetection layer [12] 3, the layers 3a and 3b are repeated 40 times.

Page 18, paragraph starting at line 35, has been amended as indicated below:

Finally, the micro-lens [11] 7A is formed on the bottom surface of the InP substrate 7, and the p-type electrode [8] 9 and the n-type electrode 10 are formed.

Page 19, paragraph starting at line 21, has been amended as indicated below:

In the photodetection [layer] device 30, the thickness of the strain-compensating layer 3b is set smaller than the thickness of the optical absorption layer 3a. Further, the strain in the strain-compensating layer 3b is increased such that the product of the tensile strain and the thickness of the strain-compensating layer becomes substantially identical with the product of the compressive strain and the thickness of the optical absorption layer 3a.

IN THE CLAIMS:

Amend claims 1, 4, 6, 8, 10 and 12 as indicated below:

1. (Amended) A semiconductor photodetection [detector] device, comprising:

a semiconductor substrate of a first conductivity type;

a photodetection layer formed on said semiconductor substrate;

a region of a second conductivity type opposite to said first conductivity type being formed in a part of said photodetection layer; and

an electrode applying an electric field to said photodetection layer via said region of said second conductivity type such that said electric field acts in a thickness direction of said photodetection layer,

said photodetection layer comprising:

a first semiconductor layer having a first thickness and accumulating therein a compressive strain and absorbing an optical radiation; and

a second semiconductor layer having a second thickness smaller than said first thickness and accumulating therein a tensile strain, said first semiconductor layer and said second semiconductor layer being stacked alternately and repeatedly in said photodetection layer,

wherein said tensile strain in said second semiconductor layer has a magnitude larger than a magnitude of said compressive strain in said first semiconductor layer.

4. (Amended) A semiconductor photodetection device as claimed in claim 1, wherein a sum of the second [thickness] thicknesses of said second semiconductor [layer] layers is smaller than a sum of the first and second thicknesses by a factor of $(0.9 \times L^{1/4} \times \varepsilon)$ [in terms of microns], wherein ε represents the strain accumulated in said first semiconductor layer in

terms of percent and L represents a sum of a total thickness of said first semiconductor layers in said photodetection layer and a total thickness of said second semiconductor layers in said photodetection layer in terms of microns.

6. (Amended) A semiconductor photodetection device as claimed in claim 5, wherein a sum of the second [thickness] thicknesses of said second semiconductor [layer] layers is smaller than a sum of the first and second thicknesses by a factor of ($0.9 \times L^{1/4} \times \varepsilon$) [in terms of microns], wherein ε represents the strain accumulated in said first semiconductor layer in terms of percent and L represents a sum of a total thickness of said first semiconductor layers in said photodetection layer and a total thickness of said second semiconductor layers in said photodetection layer in terms of percent.

8. (Amended) A semiconductor photodetection device as claimed in claim 7, wherein a sum of the second [thickness] thicknesses of said second semiconductor [layer] layers is smaller than a sum of the first and second thicknesses by a factor of ($0.9 \times L^{1/4} \times \varepsilon$) [in terms of microns], wherein ε represents the strain accumulated in said first semiconductor layer in terms of percent and L represents a sum of a total thickness of said first semiconductor layers in said photodetection layer and a total thickness of said second semiconductor layers in said photodetection layer in terms of microns.

10. (Amended) A semiconductor photodetection device as claimed in claim 9, wherein a sum of the second [thickness] thicknesses of said second semiconductor [layer] layers is smaller than a sum of the first and second thicknesses by a factor of $(0.9 \times L^{1/4} \times \varepsilon)$ [in terms of microns], wherein ε represents the strain accumulated in said first semiconductor layer in terms of percent and L represents a sum of a total thickness of said first semiconductor layers in said photodetection layer and a total thickness of said second semiconductor layers in said photodetection layer in terms of microns.

12. (Amended) A semiconductor photodetection device as claimed in claim 11, wherein a sum of the second [thickness] thicknesses of said second semiconductor [layer] layers is smaller than a sum of the first and second thicknesses by a factor of $(0.9 \times L^{1/4} \times \varepsilon)$ [in terms of microns], wherein ε represents the strain accumulated in said first semiconductor layer in terms of percent and L represents a sum of a total thickness of said first semiconductor layers in said photodetection layer and a total thickness of said second semiconductor layers in said photodetection layer in terms of microns.